Data mining for gender differences in tinnitus

Conference or Workshop Item

Data Mining for Gender Differences in Tinnitus

Michael P. Oakes, M. Naveed Anwar and Christo Panchev

***Abstract*—We perform data mining on the publicly available Tinnitus Archive. A number of statistically significant associations with gender were found using the Chi-squared test. These were age, onset rapidity, tinnitus localisation, number of tinnitus sounds heard, sleep interference due to tinnitus, feeling tired and ill because of tinnitus, index of noise exposure and subjective tinnitus pitch. No other associations with gender were statistically significant. In each case where a factor was found to be associated with gender, we analysed the data further by examining the standardised residuals. These showed that more men with tinnitus were younger, and more men had experience of noise exposure. Women were more likely to hear more than three sounds in their tinnitus, hear it in both ears, experience gradual onset of tinnitus, and hear it at lower pitches. Our findings are confirmed by the use of a measure derived from market basket analysis, that of lift.**

***Index Terms*—Data Mining, Tinnitus, Audiology, Standardised Residuals**

I. Introduction

TINNITUS is suffering from ringing in the ears. Many people experience it at some time or another, but for about 2% of the population it severely affects the quality of life. The Tinnitus Archive [1] holds data formerly contained in the OTDA (Oregon Tinnitus Data Archive). It contains data only on clinically-significant subjective tinnitus, which is tinnitus that can only be heard by the person experiencing it. The ratio of male to female patients presenting at the Oregon Tinnitus Clinic is typically about 70:30. Much of the information was obtained by patient self-reporting, elicited by questionnaire. Altogether there are 29 data sets in data set 2. In a few cases, overall Chi-squared values have already been calculated. The Tinnitus Archive contains no information by which individual patients could be identified [2]. In this study we make use of Data Set 2, which contains data obtained from 873 consecutive patients seen at the Oregon Health and Science University Tinnitus Clinic between 29th December 1981 and the 11th April 1989. It is a large, representative, subset of Data Set 1 (which holds data for 1630 patients), with the advantage that the data is broken down by gender.

An analysis of gender-based differences in tinnitus derived from this data was given by Meikle and Griest [3]. In this study we go further, firstly by using the Chi-squared test to examine the statistical significance of every association between gender and the factors in the Tinnitus archive, which are listed in Table 2. The only exception is that we do not analyse the audiometric data, as this is in the form of real-valued, continuous data, and the Chi-squared test needs categorical data to work with. Secondly, we decompose all the significant associations into standard residuals, which show us exactly which questionnaire responses were most responsible for the overall association. We also analyse the results using three measures derived from market basket analysis, namely support, confidence and lift.

Meikle and Griest [3] found that relatively many men suffered from tinnitus caused by long periods of noise exposure, since many of them had worked in heavy industry. Related to this, high frequency (pitch) losses are seen significantly more often in men. More men than women report that their tinnitus is localised to both sides rather than being in one ear only. They found gender differences ($p < 0.005$) in the perceived quality of the predominant tinnitus sound, since more women than men described “ringing”, “clear tone”, “buzzing”, or “whistling” than men. In terms of the perceived pitch of their tinnitus, the proportions of men and women were not greatly different, but still significant: more women reported tinnitus at lower pitches in the range 100 – 2500 Hz, while more men reported it at very high frequencies, > 8500 Hz.

Erlandson and Holgers [4] found that males with tinnitus generally tended to ignore psychological ill-health more than women. Younger women tinnitus sufferers reported more health problems compared with a normal female control group in terms of lack of energy, “pain”, emotional reactions and sleep disturbance. The mean age of male tinnitus sufferers was significantly greater than that of female sufferers. There were gender differences ($p < 0.01$) in that more women with tinnitus than men reported pain, reduced mobility, lack of sleep and lack of energy. The greatest gender difference in these respects were in young and middle-aged groups. In direct contrast to this, Holgers [6] found no gender differences in the prevalence of tinnitus in 7 year-old children. Pinto et al. [5] found no significant correlations at all between gender, age, hearing loss and the

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degree of annoyance caused by tinnitus. Vanneste et al. [7] showed that typically, pain, sleep loss and depression are perceived as more severe by female tinnitus patients. Although the overall distress levels do not differ between the sexes in tinnitus, females are more affected by this distress than males.

II. Methodology

The Tinnitus Archive Data set 2 contains data on many aspects of tinnitus (such as predominant sound, pitch, and social factors) broken down by gender and in the form of contingency tables. An abridged version of one table of the Archive, that which cross-tabulates sound type (for patients with only one predominant sound type recorded) is shown in Table 1:

TABLE I
Example Calculation of Standardised Residuals

Sound type	Male	Female	Row total
Ringing	163 (158.6) [0.41]	55 (59.4) [-0.67]	218
Hissing	26 (24.7) [0.28]	8 (9.3) [-0.45]	34
Clear Tone	33 (27.6) [1.05]	5 (10.4) [-1.69]	38
Ocean Roar	5 (10.2) [-1.61]	9 (3.8) [2.61 **]	14
Other	72 (77.8) [-0.76]	35 (29.2) [1.22]	107
Column total	299	112	Grand total = 411

We first calculate an overall Chi-squared value (X^2) which will tell us if there is a statistically significant difference between men and women in the main type of noise they hear in their tinnitus. In this case, Chi-squared is 16.38, so we can be 99% confident that there is an overall difference between the genders in this respect. We then calculate a value called a standardised residual for each cell in the table, and these values are shown in square brackets. Standardised residuals are also related to statistical significance. In the example above, the value of 2.61 means that we can be 99% confident that women are more prone to hearing an ocean roar sound than men. In this paper *** denotes 99.9% confidence, ** denotes 99% and * denotes 95%. Thus we can see exactly which differences between the two genders are responsible for the overall difference between them.

The numbers of males and females with each tinnitus type are called the "Observed" frequencies, and these are shown in Table 1 without parentheses. From these, we can calculate the "Expected" frequencies, which are the frequencies of each tinnitus type for each gender we would have seen if their relative frequency were identical in both genders. To calculate the expected frequency for a cell, we multiply the column total (total number of patients of that gender) by the row total (total number of patients with that tinnitus type), then divide by the grand total (the total number of patients in the sample). The expected frequencies for each tinnitus type for each gender are shown in parentheses. The standardised residual is found by subtracting the expected frequency from the observed frequency, then dividing this difference by the square root of the expected frequency. The formula for each cell of the original table is:

$$\sqrt{\frac{(O-E)^2}{E}} \quad (1)$$

Examination of the standard residuals is a good way to decompose the overall association measured by the Chi-squared value, because there is a close mathematical relationship between the two. If we square the residual for every cell, then add all these squared residuals together, we obtain the overall Chi-squared value. Each standard residual behaves as a z score, and thus may be related to statistical significance (Field, 2009:698-699). For example, if the standard residual is 3, the corresponding p value can be found using the Excel equation 2 * NORM.S.DIST(3).

While the Chi-squared test can show whether a relationship between two variables is statistically significant, it does not actually show the strength of this relationship. It is possible for a relationship to be highly significant, but weak. This is apt to occur when we have large sample sizes – if an association exists at all, we can obtain significant results just by increasing the sample size. A value of Chi-squared can be adjusted for sample size simply to divide it by the sample size (Lucy, 2005:50-51). This measure is called Phi-squared (Φ^2), and can be used as long as there are neither more than two rows nor more than two columns in the contingency table. Since all the tests in this paper consider only two genders, and thus just two columns, we can use Phi-squared alongside every Chi-squared test to show the strength of the relationship. To corroborate our results, we used three measures from market basket analysis, which are described in section 3.

III. Results

A. *Chi-squared and Phi-squared* .

A number of statistically significant associations with gender were found using the Chi-squared test, as shown in Table 2. These were age, onset rapidity, tinnitus localisation, number of tinnitus sounds heard, sleep interference due to tinnitus, feeling tired and ill because of tinnitus, index of noise exposure and subjective tinnitus pitch. No other associations with gender were statistically significant. In every case, the strength of the association was weak as indicated by the Phi-squared values. By far the strongest association according to this criterion was between gender and index of noise exposure.

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TABLE II
OVERALL ASSOCIATIONS BETWEEN GENDER AND OTHER TINNITUS-RELATED FACTORS

Data Summary	X^2	df	p	Φ^2
Age:				
Age	48.16	5	<0.0001	0.06
Tinnitus History:				
Duration	8.24	5	0.1435	0.01
Onset Rapidity	13.19	2	0.0014	0.02
Onset Factors Reported	4.04	2	0.1327	0.00
Past Intermittency	1.314	4	0.8597	0.00
Localisation changes since onset	9.37	5	0.0952	0.01
Loudness changes since onset	2.58	4	0.6304	0.00
Tinnitus Attributes:				
Present Intermittency	0.67	4	0.955	0.00
Tinnitus localisation: all locations reported	35.46	12	0.0004	0.03
Tinnitus localisation: where is tinnitus worst?	6.62	7	0.4695	0.01
Number of tinnitus sounds heard	15.87	4	0.0032	0.02
Predominant tinnitus sound(s)	0.05	1	0.8231	0.00
Loudness rating (subjective)	5.14	5	0.399	0.01
Loudness fluctuations: frequency of occurrence	10.44	5	0.0637	0.05
Loudness fluctuations: magnitude	8.60	6	0.1974	0.01
Tinnitus Severity:				
Sleep interference caused by tinnitus	6.33	2	0.0422	0.01
Feel irritable or nervous because of tinnitus	5.68	2	0.0584	0.01
Feel tired or ill because of tinnitus	8.70	2	0.0129	0.01
Difficulty relaxing caused by tinnitus	5.55	2	0.0623	0.01
Uncomfortable in quiet because of tinnitus	3.32	2	0.1901	0.00
Difficulty concentrating caused by tinnitus	0.69	2	0.7082	0.00
Harder to interact pleasantly because of tinnitus	0.81	2	0.667	0.00
Amount of effort to ignore tinnitus	0.91	3	0.1027	0.02
Amount of discomfort from usual tinnitus	6.19	3	0.1027	0.02
Interference with work activities	2.74	3	0.4335	0.01
Interference with social activities	2.19	3	0.539	0.01
Interference with overall enjoyment	6.63	3	0.0847	0.02
Audiological History:				
Index of noise exposure	306.2	8	<0.0001	0.39
Tinnitus Test Results:				
Tinnitus Pitch Match	25.78	8	0.0011	0.03

B. *Standardised Residuals*

We will now look at each of the factors which were significantly associated with gender in turn, and examine the standardised residuals to see exactly which cells in the original contingency tables contributed most to these overall associations. The results for age and gender are shown in Table 3. Here the greatest contributions to the overall association were that women with tinnitus were less likely to be in the age group 40-49, but more likely to be in the 70+ age group. Men were significantly less likely to be in the 70+ age group.

TABLE III
STANDARDISED RESIDUALS FOR GENDER AND AGE

Age (years)	Males	Females
<30	29 (34.0) [-0.85]	18 (13.0) [1.38]
30-39	108 (99.0) [0.90]	29 (38.0) [-1.46]
40-49	157 (136.6) [1.74]	32 (52.4) [-2.82 **]
50-59	170 (159.7) [0.81]	51 (61.3) [-1.31]
60-69	120 (133.0) [-1.13]	64 (51.0) [1.82]
70+	47 (68.7) [-2.61 **]	48 (26.3) [4.22 ***]

The overall association between gender and index of noise exposure is analysed further in Table 4. The statistically significant residuals show that male tinnitus sufferers are significantly more likely to have experienced noise exposure in the range 0 to 1.99, while female sufferers are likely to have experienced less noise exposure (-1.50 to -0.51).

TABLE IV
STANDARDISED RESIDUALS FOR GENDER AND NOISE EXPOSURE

Index of noise exposure	Males	Females
-1.50 to -1.01	49 (128.0) [-6.98 ***]	128 (49.0) [11.29 ***]
-1.00 to -0.51	80 (100.5) [-2.05 *]	59 (38.5) [3.31 ***]
-0.50 to -0.01	92 (81.7) [1.14]	21 (31.3) [-1.84]
0.00 to 0.49	106 (82.5) [2.59 **]	8 (31.6) [-4.19 ***]
0.50 to 0.99	104 (76.7)[3.12 **]	2 (29.3) [-5.05 ***]
1.00 to 1.49	69 (51.4) [2.46 *]	2 (19.7) [-3.98 ***]
1.50 to 1.99	42 (30.4) [2.11 *]	0 (11.6) [-3.41 ***]
2.00 to 2.49	28 (20.3) [1.72]	0 (7.8) [- 2.78 **]
2.50 +	5 (1.4) [0.73]	0 (1.4) [-1.18]

The overall association between gender and the number of tinnitus sounds heard, elicited in response to the question "Does your tinnitus consist of one sound or more than one sound?", was broken down in terms of standardised residuals as shown in Table 5. The only significant residual in this table residual shows that women tinnitus sufferers are more likely than men to experience multiple sounds in their tinnitus.

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TABLE V
STANDARDISED RESIDUALS FOR GENDER AND NUMBER OF TINNITUS SOUNDS HEARD

Number of tinnitus sounds heard	Males	Females
1 sound	360 (344.0) [0.86]	116 (132.0) [-1.39]
2 sounds	182 (182.1) [-0.01]	70 (69.9) [0.01]
3 sounds	40 (47.0) [-1.02]	25 (18.0) [1.64]
More than 3 sounds	16 (23.9) [-1.61]	17 (9.2) [2.59 **]
More than 1, unsure how many	30 (31.1) [-0.19]	13 (11.9) [0.31]

Although the Chi-squared test showed that the association between gender and sleep interference caused by tinnitus was significant overall, none of the individual residuals were significant, as shown in Table 6. However, the signs (positive or negative) of the standardised residuals show a slight tendency for men with tinnitus to lose sleep never or only sometimes as compared with women, while more women with tinnitus lose sleep often.

TABLE VI
STANDARDISED RESIDUALS FOR GENDER AND SLEEP INTERFERENCE CAUSED BY TINNITUS

Sleep loss	Males	Females
No	208 (197.3) [0.76]	64 (74.7) [-1.24]
Yes, sometimes	280 (278.5) [0.09]	104 (105.5) [-0.15]
Yes, often	119 (131.3) [-1.07]	62 (49.7) [1.74]

Although the Chi-squared test showed that the association between gender and feeling tired or ill due to tinnitus was significant overall, none of the individual residuals were significant. However, the signs (positive or negative) of the residuals shown in Table 7 show a slight tendency for women with tinnitus to feel more tired or ill than men with tinnitus.

TABLE VII
STANDARDISED RESIDUALS FOR GENDER AND FEELING TIRED OR ILL DUE TO TINNITUS

Feel tired or ill because of tinnitus	Males	Females
No	322 (303.3) [1.07]	97 (115.7) [-1.73]
Yes, sometimes	142 (149.1) [-0.58]	64 (56.9) [0.95]
Yes, often	134 (145.5) [-0.95]	67 (55.5) [1.55]

The residuals for subjective tinnitus location are shown in Table 8. Women were less likely to experience tinnitus in both ears, but more likely to experience it inside the top of the head. For the association between gender and onset rapidity, the standardised residuals showed that women were less likely to experience gradual onset of tinnitus, and more likely to experience sudden onset. These results are shown in Table 9. The overall association between gender and subjective tinnitus pitch was broken down as shown in Table 10. The statistically significant standardised residuals show that women are more likely (and men are less likely) to experience tinnitus at low pitches in the range 100 to 1499 Hz, while women are less likely to experience tinnitus at very high pitches, at or above 8500 Hz.

TABLE VIII
STANDARDISED RESIDUALS FOR GENDER AND REPORTED LOCATION OF TINNITUS

Location reported	Males	Females
Both ears	429 (399.8) [1.46]	131 (160.2) [-2.31 *]
Left ear	71 (77.8) [-0.77]	38 (31.2) [1.22]
Inside head – left	39 (42.1) [-0.48]	20 (16.9) [0.76]
Outside head – left	7 (5.0) [0.90]	0 (2.0) [-1.42]
Not sure – left	0 (1.4) [-1.19]	2 (0.6) [1.89]
Right ear	57 (66.4) [-1.15]	36 (26.6) [1.82]
Inside head – right	38 (38.6) [-0.09]	16 (15.5) [0.14]
Outside head – right	9 (6.4) [1.02]	0 (2.6) [-1.60]
Fills head	59 (63.5) [-0.57]	30 (25.5) [0.90]
Inside top of head	4 (7.9) [-1.37]	7 (3.2) [2.17 *]
Surrounds head	3 (2.9) [0.09]	1 (1.1) [-0.14]
Back of head	19 (20.0) [-0.22]	9 (8.0) [0.35]
Other answer	31 (34.3) [-0.56]	17 (13.7) [0.88]

TABLE IX
STANDARDISED RESIDUALS FOR GENDER AND ONSET RAPIDITY OF TINNITUS

Onset rapidity	Males	Females
Gradual (more than 1 month)	341 (318.5) [1.26]	96 (118.6) [-2.07 *]
Rapid (more than 1 week, less than / equal to 1 month)	4 (51.0) [-0.28]	21 (19.0) [0.46]
Sudden (less than / equal to 1 week)	201 (221.5) [-1.38]	103 (82.5) [2.26 *]

TABLE X
STANDARDISED RESIDUALS FOR GENDER AND TINNITUS PITCH

Pitch match (Hz)	Males	Females
100 – 1499	35 (49.4) [-2.05 *]	33 (18.6) [3.33 ***]
1500 – 2499	36 (39.9) [-0.62]	19 (15.1) [1.01]
2500 – 3499	65 (65.3) [-0.04]	25 (24.7) [0.07]
3500 – 4499	83 (75.5) [0.86]	21 (28.5) [-1.40]
4500 – 5499	36 (35.6) [0.07]	13 (13.4) [-0.12]
5500 – 6499	68 (70.4) [-0.29]	29 (26.6) [0.47]
6500 – 7499	32 (31.2) [0.14]	11 (11.8) [-0.23]
7500 – 8499	105 (106.0)[-0.10]	41 (40.0) [0.16]
≥ 8500	123 (109.6) [1.28]	28 (41.4) [-2.08 *]

C. *Support, Confidence and Lift*

Support, confidence and lift are three measures derived from market basket analysis. The support for a rule such as "men with tinnitus hear one predominant sound" is the percentage of questionnaire respondents who were both male and heard a single tinnitus sound. The confidence for this rule is the proportion of men with tinnitus who heard just one predominant sound. A related measure, lift, is given by the formula

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$$Lift = \frac{P(A \cup B)}{P(A).P(B)} \quad (2)$$

which is the proportion of men with just one predominant sound, divided by the product of the proportion of the sample which were male and the proportion who experience only one predominant sound. If lift is close to 1, maleness and hearing just one sound are independent of each other. If lift > 1, the two are positively correlated, and if lift < 1, they are negatively correlated.

To ensure that the market basket analysis measures give the same "ball park" answers as the statistical tests, it is sensible to start with the most significant association discovered by the Chi-squared test, namely that between gender and noise exposure. In keeping with what was found with the standardised residuals, the lift measures show that there is a positive correlation between female gender and the lowest level of noise exposure, and positive correlations between male gender and all indices of noise exposure above 0. These results are shown in Table 11.

TABLE XI
SUPPORT AND CONFIDENCE FOR GENDER AND NOISE EXPOSURE

	Males			Females		
Index of noise exposure	Sup.	Conf.	Lift.	Sup	Conf.	Lift
-1.50 to -1.01	0.06	0.09	0.38	0.16	0.58	2.61
-1.00 to -0.51	0.10	0.14	0.80	0.07	0.27	1.53
-0.50 to -0.01	0.12	0.16	1.13	0.03	0.10	0.67
0.00 to 0.49	0.13	0.18	1.29	0.01	0.04	0.25
0.50 to 0.99	0.13	0.18	1.36	0.01	0.04	0.07
1.00 to 1.49	0.09	0.12	1.34	0.00	0.01	0.10
1.50 to 1.99	0.05	0.07	1.38	0.00	0.00	0.00
2.00 to 2.49	0.04	0.05	1.38	0.00	0.00	0.00
2.50 +	0.01	0.01	1.38	0.00	0.00	0.00

The results for confidence in Table 12 show that both men and women are most likely to experience a single or at most two tinnitus sounds, while lift shows that there is a positive correlation between women and hearing more than 3 sounds. This second finding fits in with the only significant residual in Table 5, which shows that women are more likely than men to hear more than 3 sounds.
than for women. The lift for women replying "inside the top of the head" is 2.22, which confirms the corresponding positive residual. However, Table 14 also shows high lift for women responding "not sure, left". This is simply an artefact caused by the very small sample size (just two women and no men gave this response). Finally, to round off our analysis of support, confidence and lift for all the statistically significant associations, we found that the highest lift was found for the women reporting tinnitus at the lowest pitches, which was also the most significant residual.

TABLE XII
SUPPORT AND CONFIDENCE FOR GENDER AND NUMBER OF TINNITUS SOUNDS HEARD

	Males			Females		
Number of tinnitus sounds heard	Sup.	Conf.	Lift	Sup.	Conf.	Lift
1 sound	0.41	0.57	1.05	0.13	0.48	0.88
2 sounds	0.21	0.29	1.00	0.08	0.29	1.00
3 sounds	0.05	0.06	0.85	0.03	0.10	1.39
More than 3 sounds	0.02	0.03	0.67	0.02	0.07	1.84
More than 1, unsure how many	0.03	0.05	0.97	0.01	0.05	1.09

TABLE XIII
SUPPORT AND CONFIDENCE FOR GENDER AND SLEEP INTERFERENCE CAUSED BY TINNITUS

	Males			Females		
Sleep loss	Sup.	Conf.	Lift	Sup.	Conf.	Lift
No	0.25	0.34	1.05	0.08	0.28	0.86
Yes, sometimes	0.33	0.46	1.01	0.12	0.45	0.99
Yes, often	0.14	0.20	0.91	0.07	0.27	1.25

TABLE XIV
SUPPORT AND CONFIDENCE FOR GENDER AND REPORTED LOCATION OF TINNITUS

	Males			Females		
Location reported	Sup.	Conf.	Lift	Sup.	Conf.	Lift
Both ears	0.40	0.56	1.07	0.12	0.43	0.82
Left ear	0.07	0.09	0.91	0.04	0.12	1.22
Inside head – left	0.04	0.05	0.93	0.02	0.07	1.18
Outside head – left	0.01	0.01	1.40	0.00	0.00	0.00
Not sure – left	0.00	0.00	0.00	0.00	0.01	3.50
Right ear	0.05	0.07	0.86	0.03	0.12	1.35
Inside head – right	0.04	0.05	0.99	0.01	0.05	1.04
Outside head – right	0.01	0.01	1.40	0.00	0.00	0.00
Fills head	0.05	0.08	0.93	0.03	0.10	1.18
Inside top of head	0.00	0.01	0.51	0.01	0.02	2.22
Surrounds head	0.00	0.00	1.05	0.00	0.00	0.87
Back of head	0.02	0.02	0.95	0.01	0.03	1.12
Other answer	0.03	0.04	0.90	0.02	0.06	1.24

Just as there were no significant residuals for gender and sleep interference caused by tinnitus, the lift values of every cell in Table 13 show lift values all close to 1. Although not shown here, a similar correspondence between non-significant or weakly significant residuals was reflected by lift values all close to 1 for feeling tired or ill due to tinnitus (where the greatest lift was 1.25 for females responding

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"yes, often") and onset rapidity (where the greatest lift was 1.25 for females responding "sudden").

The results for confidence in Table 14 show that while both men and women are much more likely to experience tinnitus in both ears, that is the case for men more frequently

IV. Conclusion

Our results agree fairly well with those gender-related tinnitus factors found in the literature. We agree with Miekle and Griest [3] that more male tinnitus sufferers had histories of noise exposure than women, and that women have a greater tendency to report tinnitus on both sides (as opposed to in one ear only) than men. We also found low-pitched tinnitus predominant in women, and very high frequency tinnitus predominant in men. However, we did not find any significant overall association (as shown by the Chi-squared test) between gender and the quality of the predominant tinnitus sound. Unlike Erlandson and Holgers [4] we found proportionally more male tinnitus sufferers in younger age groups. Similarly to both Erlandson and Holgers [4] and Vanneste et al. [5] we found that female tinnitus sufferers were more likely to report loss of sleep. At present, only summary data for groups of patients are available from the Tinnitus archive.

We have shown that the standardised residuals corresponded well with lift for our data. Support and confidence are much harder to interpret, as the thresholds above which rules are deemed "interesting" are domain-specific.

It is our hope that individual patient data will come available in future, to enable this type of analysis to be conducted for a range of demographic variables other than gender. This will allow us to examine claims made in the literature such as sleep disturbance being correlated with tinnitus severity (perceived loudness) [13], and measures of anxiety, depression, and obsessive-compulsive MOCI scores [14]. Chung et al [12] found that the most important factor in tinnitus was the hearing level. Other factors such as smoking and shooting had no direct relation with tinnitus, but were indirectly related through the influence they have on hearing loss. This finding however suggests the idea that it would be worthwhile examining the effects of lifestyle factors in tinnitus by data mining, so that people can be advised to avoid those factors which bring on or exacerbate tinnitus.

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